TEP "Category D and E" homework problems version 1 ('21)

- submission via ITC-LMS of U Tokyo. Multiple files can be uploaded multiple times until the deadline (in early August).
- We request that the file name includes the problem number, such as E1-**.pdf or ***-D3-E4.jpeg. The ITC-LMS shows who had submitted the file (student ID and name), so the file name will not have to contain your name or ID number.
- Reports do not have to be neatly written or type-set just for the reason that the reports have to be readable for me. I do not recommend to spend extra time (for a good looking report) beyond any process that improves your understanding on the subjects.
- When you start working on a category [E] (and some of [D]) problem and get stuck in the middle, I recommend that you still submit partial results as a report. Partial results are still non-zero achievements.
- This PDF file provides links to the articles referred to here. For a journal article, you will have free access on campus, or through the SSL-VPN Gateway service off the campus.

[**D-1**] hands-on experience in **Renormalization computations in a non-renromalizable theory**: Read a paper Physica **96A** (1979) p.327 "*Phenomenological Lagrangians*" by Steven Weinberg, and derive equation (12). Alternatively, derive eq. (19.5.26) of the textbook by Steven Weinberg vol. 2.

[**D-2**] **Understanding superconductivity in a language of renormalization and effective field theory**: Read either the "Lecture 2" in a lecture note [hep-th/9210046] "*Effective Field Theory and the Fermi Surface*," by Joe Polchinski, or the Chapter 21.6 of Weinberg's textbook, and submit a summary as a report. (meant as an antidote for focusing on Lorentz-symmetric applications of QFT during the lecture)

[**D-3**] **Anomaly inflow**: Read this paper Nucl.Phys.**B250** (1985) 427–436 by C. Callan and J. Harvey, and write a summary as a report.

[**D-4**] **Renormalization of concerved current operators**: Read this paper Phys.Rev.D 73 (2006) 105019 [hep-th/0512187] by J. Collins, A. Manohar and M. Wise, write a summary or a memo and submit it as a report.

[**D-7**] **anything else** that you are interested in, that are as challenging as **D-1∼4**, and are related to renormalization/IR divergence in QFT.

[**E-1**] **How to extract parton distributions from experimental data**: With photon probe at tree level, DIS structure functions are sensitive only to a combination $\sum_i (Q_{q_i})^2 [f_{q_i}(x) + f_{\bar{q}_i}(x)]$ of quark and anti-quark PDFs. How have we managed to extract PDFs of individual quarks from experimental data?

- Explain briefly how one can distinguish quark PDF from anti-quark PDF.
- Explain briefly how one can distinguish up quark PDF from down quark PDF.
- Explain briefly how gluon PDF can be measured.

References:

- [slides] of a review talk at a JPS meeting by K. Nagano (highly recommended (written in Japanese though))
- a textbook "*Deep Inelastic Scattering*," by R.Devenish and A. Cooper-Sarkar, (Oxford U. Press)

Experimentalist students especially: just let me know if you need a support. I wish you to understand this; it is not that I want to test you.

[**E-2**] **Soft Collinear Effective Theory** Read the following papers [hep-ph/0005275] and [hep-ph/0011336] by C. Bauer et.al. and write a summary of what you have understood. [See also the Remark below]

[**E-3**] **BFKL equation (derivation)**: Read a paper [Nucl.Phys.**B415** (1994) p.373] "*Soft gluons in the infinite-momentum wave function and the BFKL pomeron*," by A. Mueller and submit a summary (or any kinds of record of reading it) as a report. [See also the Remark below] .... maybe this is a bit tough paper to read. An alternative is to read a few setions (mainly §3 and 4) of a textbook "Quantum Chromodynamics and the Pomeron" by J. Forshaw and D. Ross (Cambridge U. Press).

[**E-4**] **duality between DGLAP and BFKL** Read a lecture note [hep-ph/0001157] by G. Altarelli et.al. and write a summary of what you have understood. [See also the Remark below]

[**E-5**] **1-loop results by unitarity**: Read such papers as [hep-ph/9409265] by Z. Bern et.al., and learn how to combine tree-level correlation functions under the unitarity principle to construct 1-loop correlation functions. Then write a summary of what you have understood about the notion of cut constructibility. If you have further curiosity, you might also be interested in looking at such papers as [hep-ph/0609191] by C. Anastasiou et.al. on the D-dimensional unitarity method. [See also the Remark below]

- **a Remark** common to many of the assignments above: If it is possible, it is a very good idea also to try to compile a list of things you have not understood yet, not just to write a summary of what you have understood in your own words. It is much better if your list is not just a collection of key words, but is written in the form of wh-question sentences (including "whether"). Acknowledging by yourseof that you are not done yet and also identifying a clear next target is often the first step in proceeding to the next stage of understanding; even when you do not have an extra time to spend on the subject, it is a meaningful thing to leave such one more step (a list) before you go away from the subject.